The 10.000 CI 60Co facility and the 3.000 Ci 60Co gamma cell

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The 10000 Ci ^{60}Co facility and the 3000 Ci ^{60}Co gamma cell

by

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Abstract

The report describes the two gamma irradiators and their calibration.

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Contents

1. Introduction

The loooo Ci ^{60}Co facility and 3ooo Ci ^{60}Co gamma cell at the Accelerator Department were reloaded during January 1973. The source strength after reloading was by February 1, 1973, 11ooo Ci for the ^{60}Co facility and 37oo Ci for the ^{60}Co gamma cell.

After reloading a new calibration of the dose rates and dose distribution in the two facilities were carried out. This report describes the facilities and the results of the calibration.

2. Description of the ^{60}Co facility

A schematic drawing of the facility is shown in fig. 1. The eight sources can be in four positions, either in the storage position in a lead box at the bottom or in three irradiation positions in which four sources are located at each side of the irradiation tube. The samples are irradiated in metal containers. The container is rotated through the irradiation tube (a point on the surface of the container describes a helical line). The dimensions of the containers for the three tubes are:

tube 12 - diameter 18o mm, length looo mm
tube 22 - diameter loo mm, length looo mm
tube 32 - diameter 58 mm, length looo mm

The horizontal movement of the container is coupled to the rotation through two gears. Gear 1:1 gives 6.25 mm per rotation or o.16 rotations per mm, gear 1:3o gives o.2o8 mm per rotation or 4.o8 rotations per mm. Samples to be irradiated are placed in the "start" position (in a container) where the dose rate is ∼2% of the maximum dose rate. The sources are then raised from the lead box to the irradiation position, and the container is moved through the irradiation tube to a position where the dose rate is back to ∼2% of the maximum dose rate. The sources are then lowered automatically to the lead box. The "start" and "end" positions for the three tubes are:

	"start" pos.	"end" pos.
tube 12	- 35o mm	+ 35o mm
tube 22	- 25o mm	+ 25o mm
tube 32	- 18o mm	+ 18o mm

"Zero" position is the centre line of the sources, where the dose rate is maximum.

The dose given to a sample is determined by the speed of the container and is controlled by maintaining the predetermined speed and by recording the number of rotations for the irradiation. An ion-chamber located near tube 22 and connected to an instrument in the control room indicates whether all the sources are brought into irradiation position.

Detailed operation instruction is given in app. 1.

3. Calibration of the ^{60}Co facility

3.1. Calibration method

The Fricke dosimeter with $G(Fe^{+++}) = 15.6$ was used for dose calibration. Red perspex, type 4034, 1 mm thickness, was used for dose distribution measurements. Glass ampoules were used in all irradiations of the Fricke dosimeter and all dosimeters were surrounded by wood or nylon matrix in order to secure electron equilibrium. Axial as well as radial dose distributions were measured together with a calibration of a reference position.

3.2. Dose distribution along the axes of the tubes

The dose distribution along the axes of the tubes (fig. 2) was measured with strips of red perspex between two 12 mm wooden pieces. The irradiations were done with all 8 sources in irradiation position and the middle of the container in "zero" position.

The dose rate in "zero" position was measured to be (February 1, 1973):

	Max. dose rate Mrad/h
tube 12	0.62
tube 22	1.6
tube 32	3.9

3.3. Dose distribution in the container

The dose distribution across the containers and along the axes was measured during normal irradiation procedure (rotation of the container); the results are shown in figs. 3 and 4. The variation of the doses at the ends of the containers is due to shielding from the container bottom and the driving spindle.

3.4. Dose calibration

The relationship between the horizontal speed of the container and the dose was measured in the axes of the three tubes. The dosimeters were placed in a nylon tube of a wall thickness of 12 mm located in the axis of the container. The horizontal speed corresponding to a dose of 1 Mrad as measured on February 1, 1973 was:

tube 12	3.19 mm/min
tube 22	5.61 mm/min
tube 32	11.46 mm/min

Irradiation with doses lower than 3 krad requires excessive container speeds when all 8 sources are in use, in this case 4 or only 1 source can be used.

The 4 sources in the right and source no. 4 are applied in these cases. The speed corresponding to a dose of 1 Mrad as measured as at February 1, 1973 was:

tube 12	1 source	o.424 mm/min
tube 22	4 sources	2.65 mm/min

3.5. Transient doses

During the raise of the sources from the lead box to the irradiation position and back a sample in the "start" or in the "end" position will receive a small dose, the transient dose. Using 8 sources the transient dose for all tubes was as at February 1, 1973, 125 rad $\pm$ 25 rad. At a position lo cm before "start" position (or after "end" position) the transient dose was 5o rad $\pm$ lo rad. In zero position (at max. dose rate) the transient dose was 2,5oo rad $\pm$ 5oo rad.

4. Description of the ^{60}Co gamma cell

A simplified drawing of the ^{60}Co gamma cell is shown in fig. 5. The irradiation chamber has the dimensions: Height 2oo mm, diameter 122 mm. Through the upper shielding plug there are 4 tubes leading to the irradiation chamber; these tubes can be used for electric cables, cooling water, etc.. Two of the tubes have a diameter of 6 mm and the other two tubes a diameter of 9 mm. The chamber can be opened in the full diameter and cylinders up to 12o mm can be inserted. The chamber can be in two positions,

the loading position where the chamber can be opened after turning the movable top shielding, and the irradiation position where the chamber is next to the sources. The 8 sources are contained in a source ring that can be rotated around the irradiation chamber. The irradiation time can be preset on a timer so that the chamber is raised automatically from irradiation position to loading position when the irradiation is finished.

Detailed operation instruction is given in app. 2.

5. Calibration of the ^{60}Co gamma cell

5.1. Calibration method

The Fricke dosimeter with $G(F^{+++}) = 15.6$ was used for dose calibration. Red perspex, type 4034, 1 mm thickness, was used for dose distribution measurements. Glass ampoules were used for the Fricke dosimeter and all dosimeters were packed in a wood or nylon matrix in order to secure electron equilibrium.

Axial as well as radial dose distributions were measured together with a calibration of a reference position.

5.2. Dose distribution in the chamber

The dose distribution in a vertical plane through the centre axis of the chamber was measured with a sheet of red perspex placed between two 15 mm wooden plates. The irradiation was done with source rotation, 20 rotations per min. Fig. 6 shows the relative dose distribution in the chamber.

5.3. Dose calibration

The dose rate in the centre of the chamber was measured with the Fricke dosimeter in 30 ml spherical cells. The dose rate as of February 1, 1973, was 358 krad/hour. A cylindrical lead shield with outer diameter 110 mm and inner diameter 42 mm is used to reduce the dose rate in the centre of the chamber. With this shielding the dose rate as at February 1, 1973, was 56.5 krad/hour.

5.4. Transient dose

It takes about 16 sec. to bring the irradiation chamber from loading to irradiation position and up again. During this period a Fricke dosimeter

in the centre of the chamber receives a dose of 360 rad $\pm$ 50 rad (February 1, 1973). The minimum irradiation time with automatic timing is 0.6 sec., hence the minimum reproducible irradiation dose is 420 rad (February 1, 1973). With lead shielding the minimum reproducible dose in the centre is reduced to 65 rad (February 1, 1973).

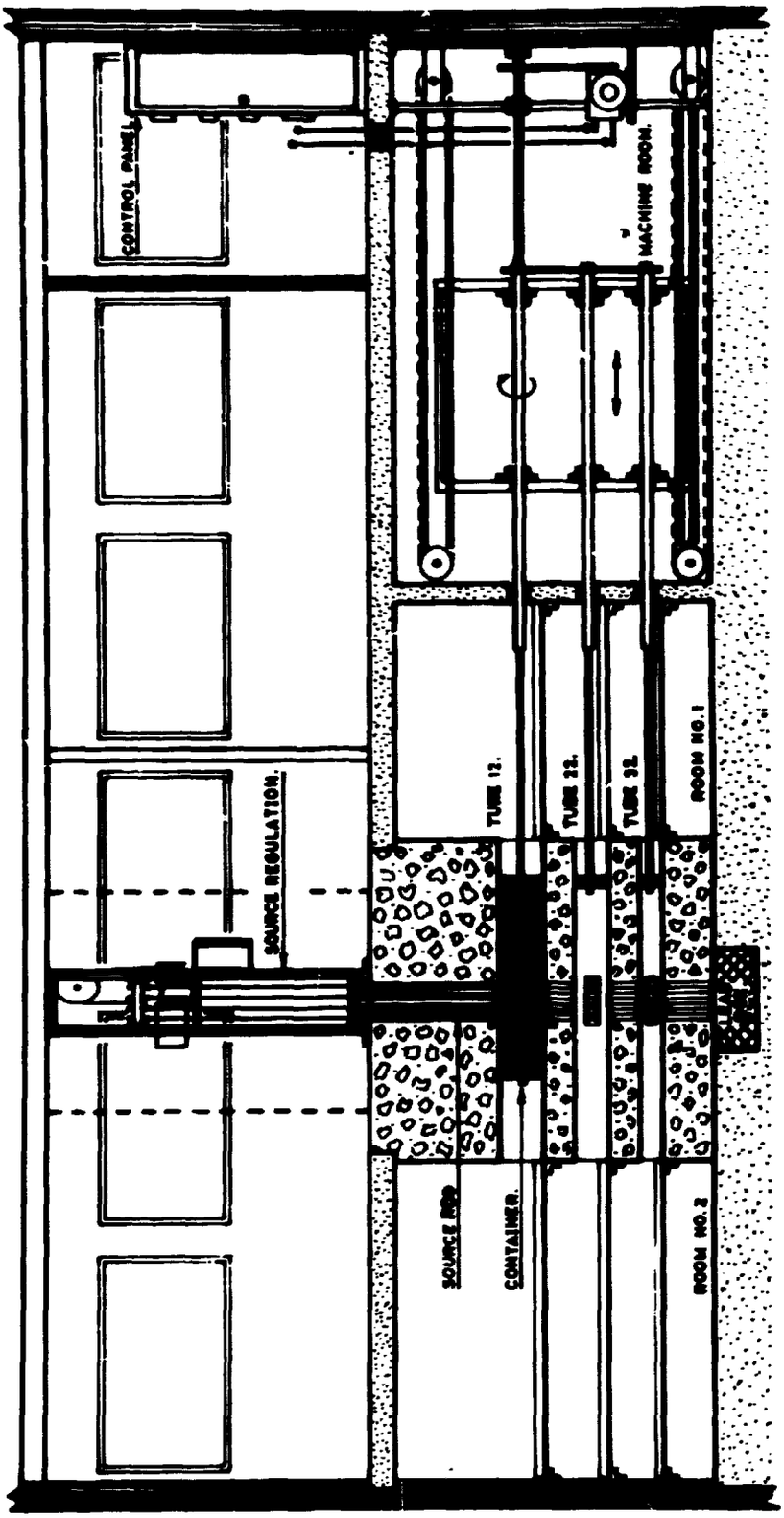

FIG. 1

The loooo Ci ^{60}Co facility.

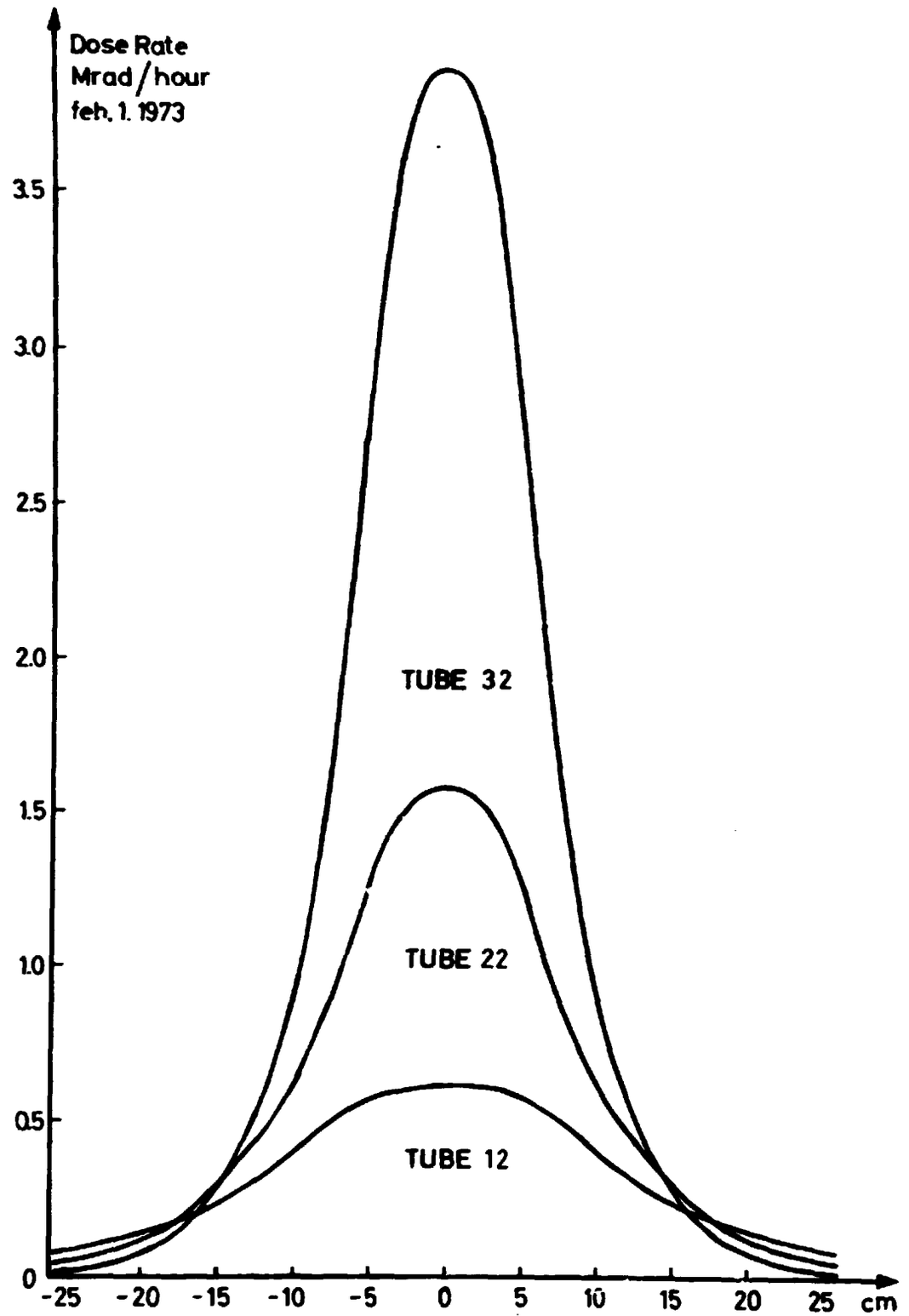

FIG.2

Dose rate variations along the irradiation tubes of the loooo Ci ^{60}Co facility.

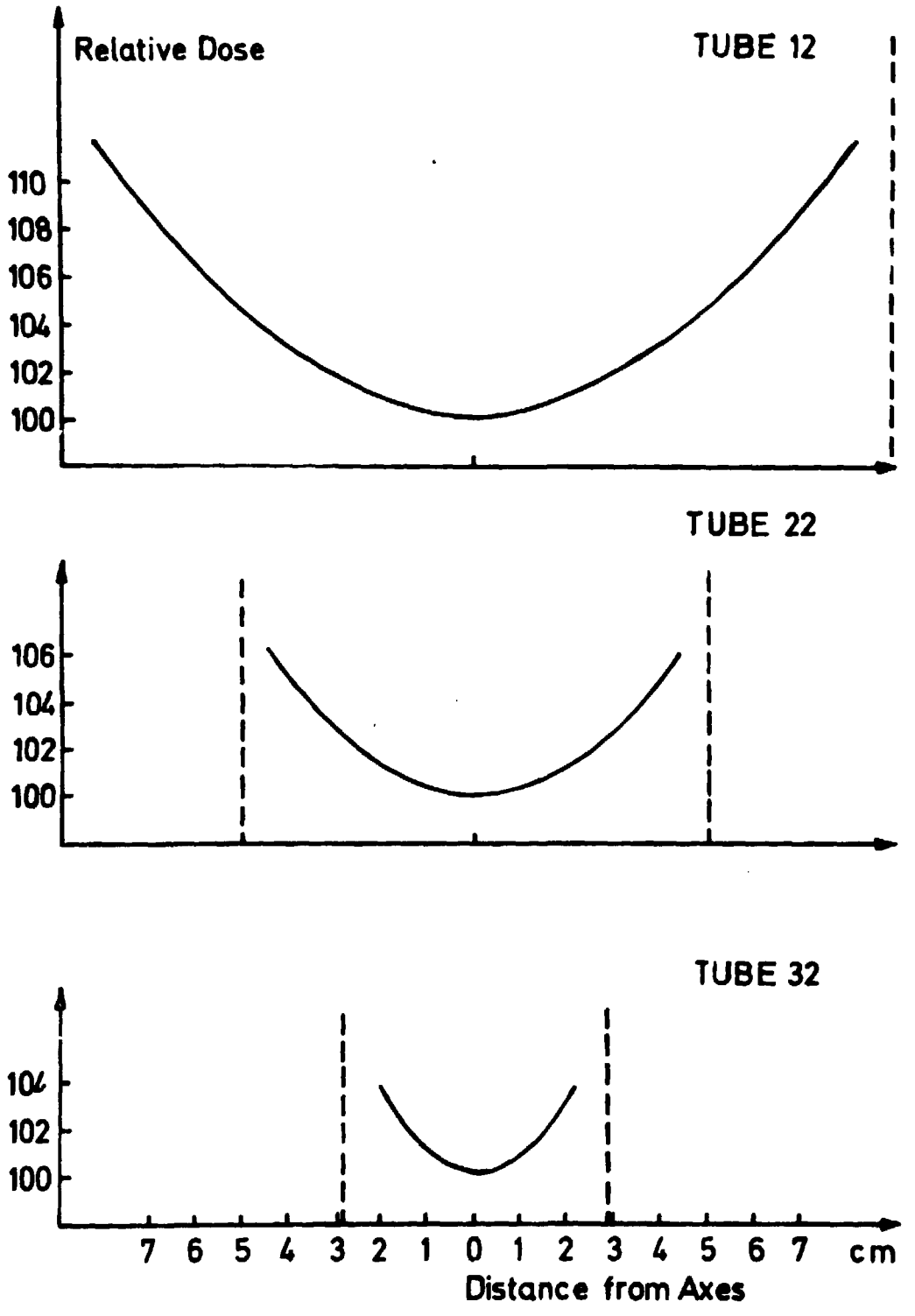

FIG. 3

Variation of relative dose across the three containers for the loooo Ci ^{60}Co facility.

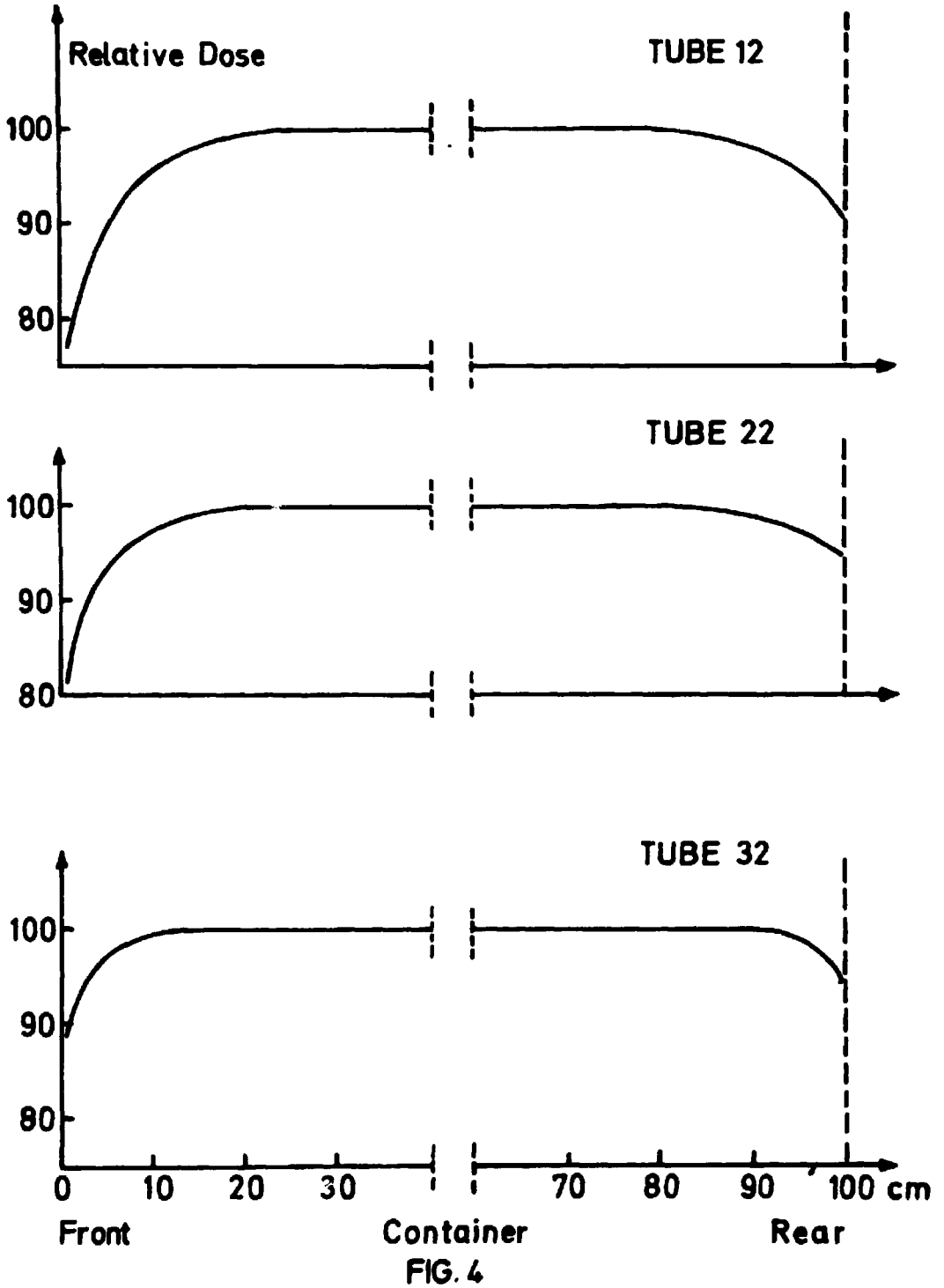

FIG. 4

Variation of relative dose along the centre line of the three containers for the loooo Ci ^{60}Co facility.

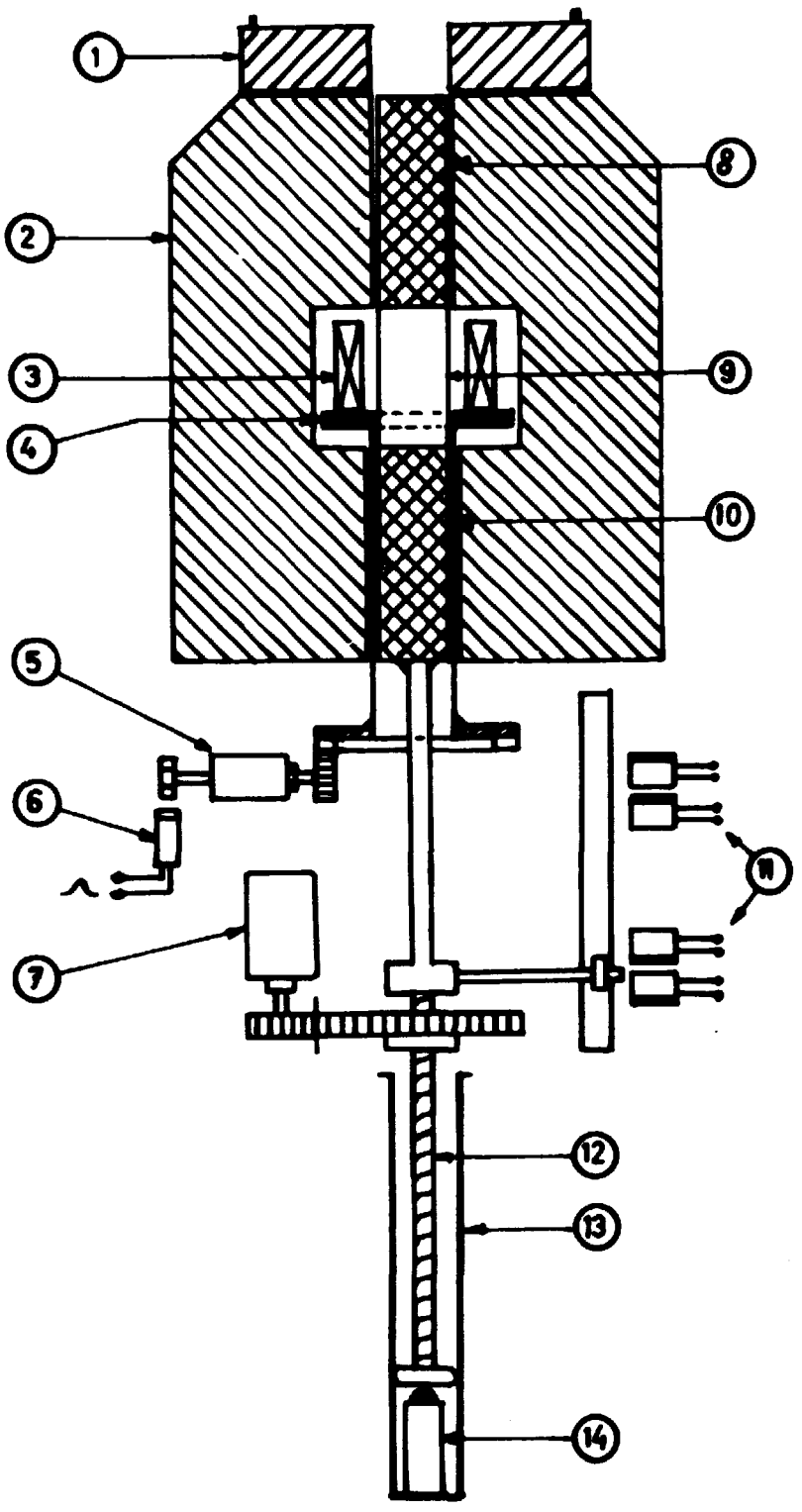

FIG.5

The 3ooo Ci ^{60}Co gamma cell.

1. Top shielding, 2. Lead container, 3. Sources, 4. Source ring, 5. Motor for source rotation, 6. Rotation indicator, 7. Motor for transport of irradiation chamber, 8. Top plug, 9. Irradiation chamber, 1o. Axis for source ring, 11. Switches, 12. Spindle, 13. Spindle protection, 14. Shock absorber.

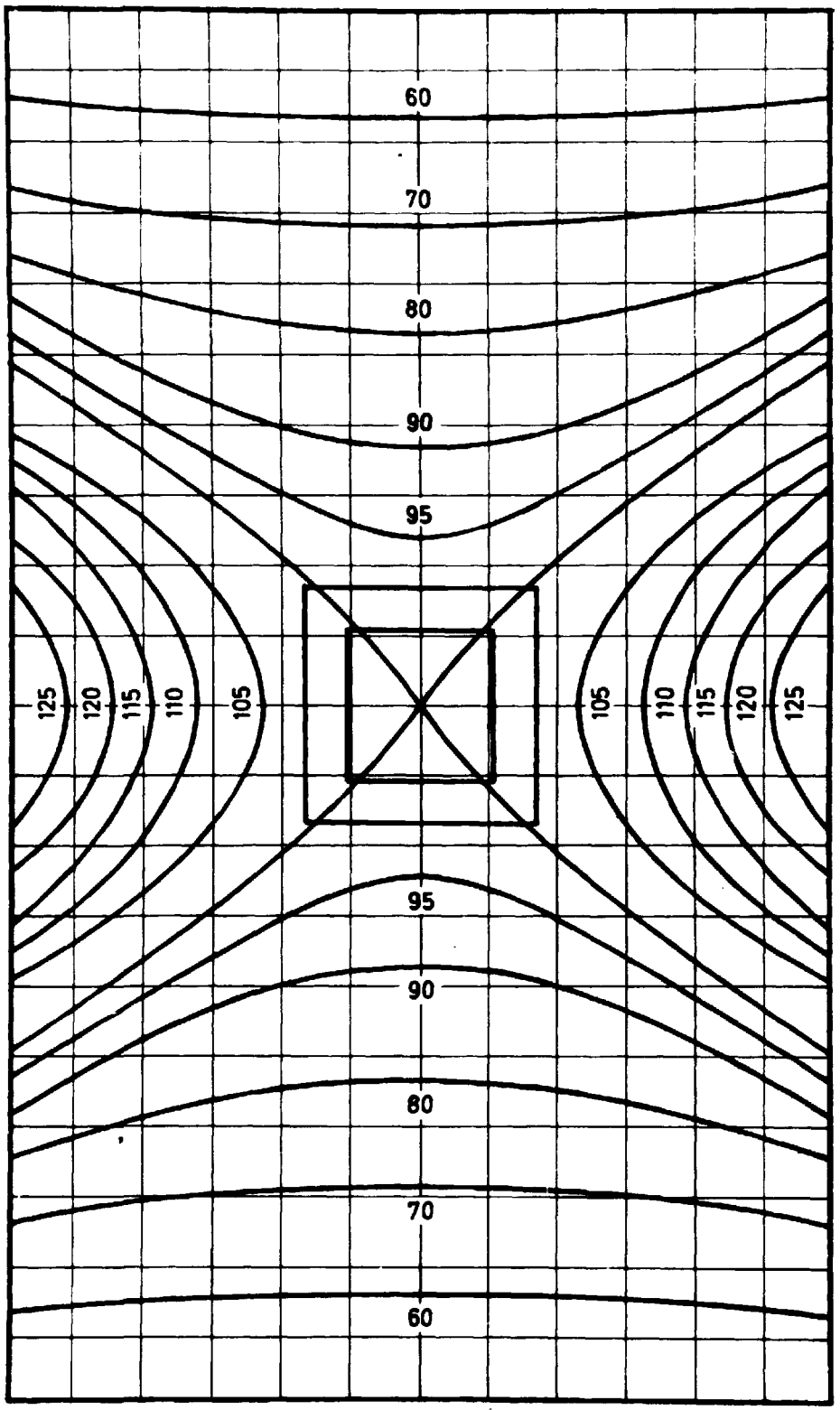

FIG. 6

Relative dose distribution in the irradiation chamber of the 3000 Ci ^{60}Co gamma cell. The two squares in the centre represents 100 $\pm$ 1% and 100 $\pm$ 2%.

Appendix 1:

Detailed operation instruction for the 1000c Ci ^{60}Co facility.

1. Irradiation

A sample is irradiated by pulling it through the irradiation field while it is rotated. The irradiation field is the distance the whole sample travels from "start" to "end" position. A sample of a length L mm has to travel 500 mm + L mm in tube 22. The length of the sample cannot be more than 1000 mm (container length).

The motorspeed can be varied between 60 and 5700 rotations per min. The driving system has two gears, 1:1 and 1:30. Gear 1:1 gives 0.617 mm horizontal movement of the container per motorrotation (or 1.62 rotations per mm), gear 1:30 gives 0.0206 mm per rotation (or 48.3 rotations per mm). Gear 1:30 is chosen when the number of rotations per min. in gear 1:1 is under 160 as the transportation system is more stable at moderate and high motorspeed.

2. Setting of container speed

The number of rotations per min. for a given dose D rad and a sample length L mm is calculated as follows:

a) The horizontal speed corresponding to 1 Mrad is corrected for source dacay.
b) The actual horizontal speed, V, for D rad is calculated.
c) The number of rotations per min., R, is calculated (for gear 1:30, R = 48.6 rotations/mm x V mm/min.).

R is preset on the control panel.

The irradiation time, t, is calculated from the equation

$$t = \frac{L + 500\ (mm)}{V\ (mm/min.)} \qquad \text{(for tube 22)}$$

3. Control of dose

The total number of rotations during the irradiation is counted and the irradiation time is measured. The dose given to the sample D_s can be calculated from the equation:

$$D_s = D \times \frac{n}{N/t}$$

where

D is the wanted dose

n is the preset number of rotations/min.

N is the total number of rotations

t is the irradiation time

Appendix 2:

Operation instruction for the 3000 Ci ^{60}Co gamma cell.

The main switch for the gamma cell must be switched off in order to open the top shielding and reach the irradiation chamber. After samples have been placed in the irradiation chamber and the top shielding have been closed the main switch is switched on. The top shielding is now located in position and an alarm goes on. The alarm is stopped by pressing the "reset" button. Now the irradiation time is preset on one of the timers (0-16 min. and 2.4 min. - 100 hours). The rotation of the sources is switched on.

By pressing the button "ned" the irradiation is started. When the irradiation time is finished the chamber is automatically brought up to loading position. The main switch is switched off and the top shielding can be opened.